SYLLABUS

PHYSICS 441/542
INTRODUCTION TO NUCLEAR & PARTICLE PHYSICS

FALL 2017

INSTRUCTOR CONTACT INFORMATION

Instructor: Prof. Frank Geurts
Office: Herman Brown Hall 236
Email: geurts@rice.edu
Office Hours: Tuesday 1-2pm, Friday 1-2pm, or by appointment.

MEETING TIME:
Tuesday/Thursday 10:50 - 12:05 - Herman Brown Hall 427
(With agreement of the course members, some class meetings may be rescheduled to alternate times to facilitate instructor's travel schedule.)

PREREQUISITES
The student is expected to be familiar with Quantum Mechanics at the level of PHYS 311/312 and Special Relativity from PHYS 202.

COURSE DESCRIPTION & OBJECTIVES
A rigorous first-principles treatment of particle and nuclear physics requires quantum field theory, a second year graduate course, and such an approach to the subject demands more than one semester of study. However, a qualitative understanding of the essential physical concepts and phenomena is still possible with an undergraduate background in quantum mechanics and special relativity.
This course is a broad survey of current knowledge in nuclear and particle physics. The emphasis is on experimental results and how they led to our current understanding of the strong, electromagnetic, and weak interactions. In this context, the phenomena of nuclear and particle physics are described. Th concepts that drove the development of modern particle physics theory, the standard model, are introduced throughout the course and used to build physical insight and understanding. Key concepts include symmetries, conservation laws, gauge symmetries and interactions. Important applications of nuclear and particle physics and some recent advances are discussed in detail.

TEXTBOOK
Nuclear and Particle Physics: An Introduction, **Second Edition**
B.R. Martin
J. Wiley & Sons
ISBN 978-0-470-74275-4
This book is available through Amazon and should be available through the Rice Book Store.
Additional readings will be made available in Canvas.

OTHER RESOURCES
The following books provide additional material and alternative approaches to the main textbook.
- *Particles and Nuclei: An Introduction to the Physical Concepts* 7th Edition, B.Povh, K. Rith (Springer)
  Very good book at a similar level as Martin's textbook. The new and significantly updated 7th edition came available in 2015. It's worth considering as additional material.
  The 6th edition is available online through Fondren Library at http://link.springer.com/book/10.1007/3-540-36684-9/page/1

- *Introduction to Elementary Particles* 2nd Edition, D. Griffiths (Wiley)
  Favored by many for a more rigorous, theoretical approach. Limited treatment of experimental aspects, especially detectors.
- *Introduction to High Energy Physics* 4th Edition, D. Perkins (Addison-Wesley)
  A classic broad survey text, now somewhat dated.
- *Particle Physics*, 3rd Edition B. R. Martin & G. Shaw (J. Wiley & Sons)
  A large overlap with our textbook, with a stronger focus on particle physics.
- Introductory Nuclear Physics, K. Krane (J. Wiley & Sons)
  Very comprehensive and great introduction to nuclear physics. A classic.
- *Quarks and Leptons*, Halzen and Martin, (Wiley).
  A graduate level textbook.

Homework:

Homework will be assigned on Canvas and handed in for credit. Solutions will be provided to aid in understanding of the material. Students are permitted to discuss the homework with each other. However, the assignments should be completed based on each student's individual work.

Examinations:

A take-home midterm exam and take-home final exam will be given during the course. These are "open book" and "open note" exams. No collaboration or discussion on the exam questions is permitted. Questions may only be addressed to the instructor.

PHYS 542 Project:

The graduate course includes an additional project assignment to be completed by the end of the course. Details of the project will be distributed mid-way through the course.

Course Grade PHYS 411:

40% homework
30% midterm exam (take home)
30% final exam (take home)

Course Grade PHYS 542:

20% homework
30% midterm exam (take home)
30% final exam (take home)
20% project

Rice Honor Code

In this course, all students will be held to the standards of the Rice Honor Code, a code that you pledged to honor when you matriculated at this institution. If you are unfamiliar with the details of this code and how it is administered, you should consult the Honor System Handbook at http://honor.rice.edu/honor-system-handbook/. This handbook outlines the University's expectations for the integrity of your academic work, the procedures for resolving alleged violations of those expectations, and the rights and responsibilities of students and faculty members throughout the process.

Disability Support Services

If you have a documented disability or other condition that may affect academic performance you should: 1) make sure this documentation is on file with Disability Support Services (Allen Center, Room 111 / adarice@rice.edu / x5841) to determine the accommodations you need; and 2) talk with me to discuss your accommodation needs.

Syllabus Change Policy

This syllabus is only a guide for the course and is subject to change with advanced notice.

COURSE SCHEDULE (cf. Canvas for any modifications - v1)

Date	TOPIC	READINGS
AUG 22	Basic Concepts: introduction	Ch. 1
Aug 24	Basic Concepts: special relativity, quantum mechanics	App. A, B
Aug 29	Basic Concepts: quantum numbers, conservation laws	Ch. 1
Aug 31	Basic Concepts: interactions & observables	Ch. 1
SEP 5	Nuclear Phenomenology (read only)	Ch. 2, 7
Sep 7	Nuclear Phenomenology: the nucleus	Ch. 2, 7
SEP 12	Nuclear Phenomenology: nuclear decays & interactions	Ch. 2, 7
Sep 14	Nuclear Phenomenology: nuclear decays & interactions	Ch. 2, 7
Sep 19	Particle Phenomenology: leptons & interactions, neutrinos	Ch. 3
Sep 21	Particle Phenomenology: neutrinos & mixing	Ch. 3
SEP 26	Particle Phenomenology: quarks & interactions	Ch. 3
Sep 28	Particle Phenomenology: hadrons	Ch. 3
OCT 3	Experimental Methods: particle beams & interactions with matter	Ch. 4
Oct 5	Experimental Methods: electromagnetic/hadronic interactions	Ch. 4
Oct 10	no class: midterm recess	
Oct 12	Experimental Methods: particle detectors	Ch. 4
OCT 17	Quark Dynamics and Strong Interactions: QCD, Color	Ch. 5
Oct 19	QCD: color confinement, jets, asymptotic freedom	Ch. 5
Oct 24	Quark Dynamics: deep inelastic scattering	Ch. 5
Oct 26	Weak Interaction: parity violation, spin structure of weak interaction	Ch. 6
Oct 31	Weak Interaction: W, Z bosons; charged, neutral currents	Ch. 6
Nov 3	Weak Interaction: quark mixing & CP violation	Ch. 6
Nov 7	Weak Interaction: neutral current & Z coupling	Ch. 6
Nov 9	Applications of Nuclear Physics - Guest Lecture on Medical Applications	Ch. 8
Nov 14	Relativistic Heavy Ion Collisions	Suppl.
Nov 16	Gauge Theory: Electro-weak Unification & Higgs Mechanism	App. D
Nov 21	Gauge Theory: Electro-weak Unification & Higgs Boson	Ch. 9.3
Nov 23	no class - Thanksgiving	
Nov 28	Open Questions & Future Directions	Ch. 9
Nov 30	Open Questions & Future Directions	Ch. 9